

PROCESS FLOW CALCULATIONS
Responsiveness Summary/ ROD Backup
Lower Eight Miles of the Lower Passaic River

Legend

data grouping

inputs/assumptions

TSI Assumptions - Appendix E Attachment 2

output for process flow diagrams

Calculations based on methodology found in Pre-Final Design Analysis Report Phase I Removal Action by Tierra Solutions, Inc. (TSI)
Appendix E Attachment 2.

| Parameter | Selected Remedy | | | Units | Basis/Assumption |
|---|-----------------|------------------|-------------|----------|--|
| Operational Data | Alt 2 | Alt 3 | Alt 4 | | |
| V_1 Dredged sediment in-situ volume | 9,712,347 | 3,541,588 | 1,021,263 | cy | Volume Current as of October 8, 2015. |
| $t_{h/d}$ Dredge and sediment processing plant operating time | 24 | 24 | 24 | hr/d | |
| $t_{d/w}$ Dredge operating days per week | 6 | 6 | 6 | days/wk | |
| $t_{w/y}$ Dredging weeks per year | 32 | 32 | 32 | wks/yr | 35 weeks construction season minus 3 weeks downtime |
| $P_{cy/d}$ In-situ daily production rate | 3,850 | 3,850 | 3,850 | cy/day | combined production rate for all dredges in operation; number and size of dredges will vary over project location and schedule |
| t Project duration (including downtime) | 4,796 | 1,749 | 504 | days | project duration (including downtime) |
| In-situ Sediment | | | | | |
| pw Density of water | 62.4 | 62.4 | 62.4 | lb/ft3 | |
| Gs Specific gravity of solids | 2.54 | 2.35 | 2.35 | -- | Alt 2: TSI assumption - Dredging depth are higher (more consolidated sediment); Alts 3 & 4: Based on top 3-feet sediment - FFS App G Fact Sheet |
| $\%S_1$ Percent solids by weight | 50 | 42.5 | 42.5 | % | Alt 2: TSI assumption - Dredging depth are higher (more consolidated sediment); Alts 3 & 4: Based on top 3-feet sediment - FFS App G Fact Sheet |
| w_1 Water content | 100.0 | 135.3 | 135.3 | % | $w_1 = Ww/Ws = 100*(100-\%S_1)/\%S_1$ |
| e_1 Void ratio | 2.54 | 3.18 | 3.18 | -- | $e_1 = Vv/Vs = Ww/Ws*Gs/100 = w_1*Gs/100$ |
| pd_1 Dry bulk density | 44.8 | 35.1 | 35.1 | lb/ft3 | $pd_1 = Gs*pw / (1+e_1)$ |
| p_1 Wet bulk density | 89.6 | 82.6 | 82.6 | lb/ft3 | $p_1 = pd_1 * (1+w_1)$ |
| Debris Removal | | | | | |
| $\%debris$ Percent debris by volume (med/small sized only) | 6 | 6 | 6 | % | TSI assumption - can vary from 6% - 10% |
| Vd Volume of debris | 582,741 | 212,495 | 61,276 | cy | $Vd = \%debris * V_1$ |
| V_2 In-situ volume after debris removal | 9,129,606 | 3,329,093 | 959,987 | cy | $V_2 = V_1 - Vd$ |
| W_2 In-situ sediment mass after debris removal | 11,041,793 | 3,712,075 | 1,070,425 | tons | $W_2 = V_2 * p_1$ |
| Mechanically Removed Sediment | | | | | |
| $\%S_3$ Solids content after dredging (in scow) | 35 | 30 | 30 | % | Assumption/Professional Judgement |
| w_3 Water content | 186 | 233 | 233 | % | $w_3 = 100*(100-\%S_3)/\%S_3$ |
| e_3 Void ratio | 4.72 | 5.48 | 5.48 | -- | $e_3 = w_3*Gs/100$ |
| bf_3 Bulking factor | 1.62 | 1.55 | 1.55 | -- | $bf_3 = (e_3+1) / (e_1+1)$ |
| - Volume after dredging (debris included) | 15,685,558 | 5,493,906 | 1,584,239 | cy | $= V_1 * bf_3$ |
| V_3 Volume after dredging (debris removed) | 14,744,425 | 5,164,272 | 1,489,185 | cy | $V_3 = V_2 * bf_3$ |
| Hydraulic Off-Loading | | | | | |
| $\%S_4$ Solids content | 10 | 10 | 10 | % | Assumption/Professional Judgement |
| w_4 Water content | 900 | 900 | 900 | % | $w_4 = 100*(100-\%S_4)/\%S_4$ |
| e_4 Void ratio | 22.9 | 21.2 | 21.2 | -- | $e_4 = w_4*Gs/100$ |
| pd_4 Dry bulk density | 6.6 | 6.6 | 6.6 | lb/ft3 | $pd_4 = Gs*pw / (1+e_4)$ |
| p_4 Wet bulk density | 66.5 | 66.2 | 66.2 | lb/ft3 | $p_4 = pd_4 * (1+w_4)$ |
| bf_4 Bulking factor | 6.74 | 5.30 | 5.30 | -- | $bf_4 = (e_4+1) / (e_1+1)$ |
| - Total hydraulically off-loaded slurry volume (debris included) | 65,462,316 | 18,769,669 | 5,412,478 | cy | $= V_1 * bf_4$ |
| V_4 Total hydraulically off-loaded slurry volume (debris removed) | 61,534,577 | 17,643,489 | 5,087,730 | cy | $V_4 = V_2 * bf_4$ |
| V_{w1} Dilution water (water added to make slurry) | 9,451,610,853 | 2,520,801,815 | 726,906,016 | gallons | $V_{w1} = V_4 - V_3 * 202 \text{ gal/cy}$ |
| Sand Removal | | | | | |
| $\%sand$ In-situ percent sand by weight | 23.4 | 23.4 | 23.4 | % | Assumption - FFS App G Fact Sheet |
| W_{sand1} In-situ mass of sand | 2,583,780 | 868,626 | 250,479 | wet tons | $W_{sand1} = \%sand/100 * W_2$ |
| V_{sand1} In-situ volume of sand | 2,136,328 | 779,008 | 224,637 | wet cy | $V_{sand1} = W_{sand1}/p_1$ |

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| Parameter | | Selected Remedy | | | Basis/Assumption |
|----------------------------|--|-----------------|-------------|------------|---|
| | | Alt 2 | Alt 3 | Alt 4 | Units |
| W_{fines1} | In-situ mass of fine-grained sediment | 8,458,013 | 2,843,450 | 819,946 | wet tons |
| V_{fines1} | In-situ volume of fine-grained sediment | 6,993,278 | 2,550,085 | 735,350 | wet cy |
| $\%S_5$ | Hydrocyclone underflow (wet sand) percent solids | 60 | 60 | 60 | % |
| w_5 | Water content | 67 | 67 | 67 | % |
| e_5 | Void ratio | 1.69 | 1.57 | 1.57 | -- |
| bf_5 | Shrinkage factor | 0.76 | 0.61 | 0.61 | -- |
| V_5 | Wet sand volume | 1,625,379 | 478,405 | 137,954 | wet cy |
| pd_5 | Dry sand bulk density | 58.9 | 57.2 | 57.2 | lb/ft3 |
| p_5 | Wet sand bulk density | 98.1 | 95.3 | 95.3 | lb/ft3 |
| W_5 | Dry mass of sand | 1,291,890 | 369,166 | 106,454 | dry tons |
| Sand Dewatering | | | | | |
| $\%S_6$ | Sand percent solids after dewatering | 80 | 80 | 80 | % |
| w_6 | Water content | 25 | 25 | 25 | % |
| e_6 | Void ratio | 0.64 | 0.59 | 0.59 | -- |
| bf_6 | Dewatered sand shrinkage factor | 0.46 | 0.38 | 0.38 | -- |
| V_6 | Dewatered sand volume | 986,694 | 295,897 | 85,326 | wet cy |
| pd_6 | Dry dewatered sand bulk density | 97.0 | 92.4 | 92.4 | lb/ft3 |
| p_6 | Wet dewatered sand bulk density | 121.2 | 115.5 | 115.5 | lb/ft3 |
| W_6 | Mass of dewatered sand | 1,614,862 | 461,457 | 133,067 | tons |
| De-sanded Slurry | | | | | |
| $\%S_7$ | Slurry percent solids | 7.9 | 7.9 | 7.9 | % |
| w_7 | Water content | 1,161 | 1,162 | 1,162 | % |
| e_7 | Void ratio | 29.5 | 27.3 | 27.3 | -- |
| bf_7 | Bulking factor | 8.61 | 6.77 | 6.77 | -- |
| V_7 | De-sanded slurry volume | 60,242,687 | 17,274,323 | 4,981,276 | wet cy |
| pd_7 | De-sanded slurry dry bulk density | 0.07 | 0.07 | 0.07 | dry tons/cy |
| p_7 | De-sanded slurry wet bulk density | 0.89 | 0.88 | 0.88 | ton/cy |
| W_7 | Mass of de-sanded slurry | 53,336,882 | 15,253,111 | 4,398,433 | tons |
| W_{7-dry} | Dry mass of de-sanded slurry | 4,229,007 | 1,208,466 | 348,477 | dry tons |
| Slurry Conditioning | | | | | |
| Q_{pt} | Polymer flow rate to gravity thickener | 40 | 40 | 40 | gpm |
| $\%S_{pt}$ | Polymer solids content by weight | 0.25 | 0.25 | 0.25 | % |
| V_{pt} | Volume of polymer | 276,234,285 | 100,728,282 | 29,046,311 | gal |
| W_{pt} | Mass of polymer | 1,152,761 | 420,352 | 121,214 | tons |
| W_{pt-dry} | Polymer dry solids | 2882 | 1051 | 303 | dry tons |
| Q_{clr} | Clarifier solids flow rate | 25 | 25 | 25 | gpm |
| $\%S_{clr}$ | Clarifier solids content | 0.13 | 0.13 | 0.13 | % |
| V_{clr} | Volume of clarifier solids | 172,646,428 | 62,955,176 | 18,153,945 | gal |
| W_{clr} | Mass of clarifier solids | 720,476 | 262,720 | 75,759 | tons |
| $W_{clr-dry}$ | Clarifier dry solids | 937 | 342 | 98 | dry tons |
| Gravity Thickener | | | | | |
| $\%S_8$ | Percent solids | 7.7 | 7.6 | 7.6 | % |
| | | | | | = (dry weight of desanded slurry + polymer + clarifier) / (total weight of desanded slurry + polymer + clarifier) * 100 |

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| | | Alt 2 | Alt 3 | Alt 4 | |
| w ₈ | Water content | 1,204 | 1,217 | 1,217 | % $w_8 = 100 * (100 - \%S_8) / \%S_8$ |
| e ₈ | Void ratio | 30.59 | 28.60 | 28.60 | -- $e_8 = w_8 * Gs / 100$ |
| V ₈ | Gravity thickener influent volume | 62,464,869 | 18,084,637 | 5,214,940 | cy $V_8 = V_7 + (V_{pt} + V_{clr}) / 202 \text{ gal/cy}$ |
| W ₈ | Mass of de-sanded slurry | 55,210,118 | 15,936,183 | 4,595,406 | tons $W_8 = W_7 + W_{pt} + W_{clr}$ |
| W _{8-dry} | Dry mass of de-sanded slurry | 4,232,825 | 1,209,858 | 348,878 | dry tons $W_{8-dry} = W_{7-dry} + W_{pt-dry} + W_{clr-dry}$ |
| Thickened Slurry | | | | | |
| %S ₉ | Percent solids (S%) | 15 | 15 | 15 | % TSI assumption |
| w ₉ | Water content (w) | 567 | 567 | 567 | % $w_9 = 100 * (100 - \%S_9) / \%S_9$ |
| e ₉ | Void ratio (e) | 14.39 | 13.32 | 13.32 | -- $e_9 = w_9 * Gs / 100$ |
| bf ₉ | Shrinkage factor | 0.49 | 0.48 | 0.48 | -- $bf_9 = (e_9 + 1) / (e_8 + 1)$ |
| V ₉ | Thickened slurry volume | 30,438,148 | 8,745,819 | 2,521,971 | cy $V_9 = V_8 * bf_9$ |
| V _{ow} | Gravity thickener overflow (water) volume | 32,026,721 | 9,338,818 | 2,692,970 | cy $V_{ow} = V_8 - V_9$ |
| %S _{ow} | Target water treatment influent solids content (S%) | 0.005 | 0.005 | 0.005 | % TSI assumption |
| W _{ow} | Gravity thickener overflow (water) mass | 26,992,281 | 7,870,803 | 2,269,648 | tons $W_{ow} = V_{ow} * 0.842 \text{ tons/cy}$ |
| W _{ow-dry} | Gravity thickener overflow (water) dry mass | 1350 | 394 | 113 | dry tons $W_{ow-dry} = \%S_{ow} * W_{ow} / 100$ |
| W ₉ | Thickened slurry weight | 28,217,838 | 8,065,380 | 2,325,757 | tons $W_9 = W_8 - W_{ow}$ |
| W _{9-dry} | Thickened slurry dry weight | 4,231,476 | 1,209,465 | 348,765 | dry tons $W_{9-dry} = W_{8-dry} - W_{ow-dry}$ |
| Mechanical Press Influent | | | | | |
| Q _{pp} | Polymer flow rate to presses | 20 | 20 | 20 | gpm TSI assumption |
| V _{pp} | Volume of polymer | 138,117,142 | 50,364,141 | 14,523,156 | gal $V_{pp} = Q_{pp} * 60 \text{ min/hr} * t_{h/d} * t$ |
| W _{pp} | Mass of polymer | 576,266 | 210,134 | 60,595 | tons $W_{pp} = V_{pp} * \text{conversions}$ |
| W _{pp-dry} | Mass of polymer dry solids | 1441 | 525 | 151 | dry tons $W_{pp-dry} = \%S_{pp} * W_{pp} / 100$ |
| V ₁₀ | Mechanical press total influent volume | 31,121,896 | 8,995,146 | 2,593,867 | wet cy $V_{10} = V_9 + V_{pp}$ |
| W ₁₀ | Mechanical press total influent wet weight | 28,794,104 | 8,275,515 | 2,386,352 | tons $W_{10} = W_9 + W_{pp}$ |
| %S ₁₀ | Percent solids (S%) | 14.7 | 14.6 | 14.6 | % $= 100 * (\text{thickened slurry weight} + \text{polymer dry weight}) / (\text{thickened slurry wet weight} + \text{polymer wet weight})$ |
| w ₁₀ | Water content (w) | 580 | 584 | 584 | % $w_{10} = 100 * (100 - \%S_{10}) / \%S_{10}$ |
| e ₁₀ | Void ratio (e) | 14.74 | 13.72 | 13.72 | -- $e_{10} = w_{10} * Gs / 100$ |
| Mechanical Press Dewatered Sediment | | | | | |
| %S ₁₁ | Target percent solids (S%) | 57.5 | 57.5 | 57.5 | % TSI assumption |
| w ₁₁ | Water content (w) | 74 | 74 | 74 | % $w_{11} = 100 * (100 - \%S_{11}) / \%S_{11}$ |
| e ₁₁ | Void ratio (e) | 1.88 | 1.74 | 1.74 | -- $e_{11} = w_{11} * Gs / 100$ |
| bf ₁₁ | Shrinkage factor | 0.18 | 0.19 | 0.19 | -- $bf_{11} = (e_{11} + 1) / (e_{10} + 1)$ |
| V ₁₁ | Dewatered sediment volume | 5,689,982 | 1,672,235 | 482,211 | wet cy $V_{11} = V_{10} * bf_{11}$ |
| V _{fp} | Mechanical press filtrate water volume | 25,431,914 | 7,322,911 | 2,111,657 | cy $V_{fp} = V_{10} - V_{11}$ |
| W _{fp} | Filtrate water weight | 21,434,145 | 6,171,786 | 1,779,715 | tons $W_{fp} = V_{fp} * pw$ |
| W ₁₁ | Dewatered sediment weight | 7,359,960 | 2,103,728 | 606,637 | tons $W_{11} = W_{10} - W_{fp}$ |
| Sediment Process Water | | | | | |
| V _w | Generated process water volume | 11,668,293,955 | 3,380,469,721 | 974,802,447 | gal $Vw = (V_4 - V_6 - V_{11}) * 202 \text{ gal/cy} + (V_{pt} + V_{clr} + V_{pp})$ |